# Research demonstrates method that allows inexpensive carbon materials to store hydrogen at room temperature

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Hydrogen has long been considered a promising alternative to fossil fuels for powering cars, trucks and even homes. But one major obstacle has been finding lightweight, robust and inexpensive ways of storing the gas, whose atoms are so tiny they can easily escape from many kinds of containers.

New research by a team from MIT and several other institutions analyzes the performance of a class of materials considered a promising candidate for such storage: activated carbon that incorporates a platinum catalyst, so hydrogen atoms can bond directly to the surface of carbon particles and then be released when needed.

Such a storage system could avoid the cost and weight associated with conventional hydrogen storage: Current approaches either liquefy the gas, requiring energy-intensive systems and heavy insulation to maintain a temperature of minus 423 degrees Fahrenheit; or store it under high pressure, requiring powerful pumps and robust tanks to withstand 5,000 to 10,000 pounds per square inch (psi) of pressure. Bonding the hydrogen to a highly porous, sponge-like material such as a metal hydride or activated carbon makes it possible to use ambient pressure and room temperature in storage tanks that could be lighter, cheaper and safer.

The tricky part of designing such systems is finding a storage medium that bonds the hydrogen atoms tightly enough so they don't leak away, but not so tightly that they can't be released when needed. "You have to be able to pump the gas in [at room temperature], and release it when you need it to burn," explains MIT's Sow-Hsin Chen, senior author of a paper describing the new method.

Such a storage system could be key to making hydrogen-powered cars practical and economically viable, and has been a key goal of the U.S. Department of Energy (DoE). The hydrogen fuel could be made by splitting water; fuel cells would then "burn" the fuel with no emissions at all except water vapor.

Activated carbon has been proposed as a possible storage medium that could work by bonding dissociated hydrogen atoms, but previously there was no good way of analyzing the material's behavior and optimizing its storage capability. Now, such a method has been demonstrated by a team led by Chen, MIT professor emeritus in the Department of Nuclear Science and Engineering; former student Yun Liu SM '03, PhD '05, now at the National Institute of Standards and Technology and the University of Delaware; and researchers at Taiwan's Institute of Nuclear Energy Research (including lead author Cheng-Si Tsao, who was a visiting scientist at MIT for a year working with Chen), National Tsinghua University in Taiwan and Pennsylvania State University. Their findings were reported in a paper published online in the *Journal of Physical Chemistry Letters* in August, and scheduled to appear in a forthcoming print issue.

The team analyzed the activated carbon's storage of hydrogen using a technique called inelastic neutron scattering, which they say is uniquely capable of determining whether the hydrogen in the sample exists as individual atoms or H2 molecules. This approach can also assess the gas's interaction with the storage material.

Using this method, they were able to provide convincing evidence, for the first time, that hydrogen moves into the material as a result of a phenomenon called the spillover effect, in which atoms — thanks to the presence of platinum particles as a catalyst — split off from their molecules and diffuse through the carbon, where they bond to its surface. Other researchers had suspected the spillover effect was involved, but had been unable to demonstrate that this was the case. "Although this concept had been proposed, there was a lot of debate about it in the community," Liu says.

The new analysis method should make it possible to fine-tune the properties of the activated carbon material to increase its storage capacity, Chen says. The key is to find the optimum sizes and concentrations for the particles of platinum and carbon, he adds. Ultimately, the researchers also hope to identify a catalyst more abundant and less expensive than platinum.

This storage system, once tuned to achieve the desired capacity, should be capable of storing hydrogen under moderate pressure (possibly around 500 psi), then releasing the gas on demand simply by releasing the pressure, Chen says. "When you break the hydrogen molecules down to atoms" using the spillover effect, "it binds with the material with much less binding energy, so you can pump it out easily," he says.

Provided by Massachusetts Institute of Technology

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